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Thank you for that warm introduction. (Bill Collier, Chairman) And thank you for the invitation to speak here today.

I am particularly struck by your theme: "Meeting the technology needs of the warfighter in the year 2000 and beyond" because clearly this is the mission of my own organization. And looking to how we meet future warfighting needs with technology is certainly critical for us.

Environment

You know, meetings such as this provide us an opportunity to look to the future and I want to do that with you. Charles Kettering said we should all be concerned about the future because we will have to spend the rest of our lives there. What the future has in stock for us will depend largely on what we place in stock for the future. The worst thing about the future is that it gets here faster than it used to.

In 1789, George Washington took eight days to travel the distance from his home in Mount Vernon to the scene of his inauguration in New York City. The eight days in itself is not significant. The important fact is that this is the same amount of time that it would have taken to travel that distance 1000 years before. There was no real progress in transportation in 20 centuries—since Moses or Nebuchadnezzar. Julius Caesar could have stepped from the first to the 19th century more easily than Ben Franklin into the next. Now, for the first time in history, no man dies in the same epoch in which he is born.

Understanding the future has always been central to warfighting strategy. Soviet Major General Sergei Kozlov said that "the most significant task of military science has always been defining the character of future war."

If we think back to when the Victorian era came to a close and the 20th Century came into view, would our predecessors have foreseen that in less than a single generation the greatest war in history would break out? Would they have they anticipated that in less than a single short career, they would see the emergence of the airplane, the tank, the submarine and the wireless radio -- systems that would transform forever the field of human conflict? Or would they have extolled the virtues of horse cavalry, observation balloons and the bayonet?

Much of the tragedy of the First World War stemmed from the inability of the military leaders of the day to grasp the implications of change. Their failure doomed an entire generation and led directly to a second, even more destructive global war.

It is our responsibility, that of each and every one of us, to do all in our power to see that we are ready for tomorrow, that we never, ever, allow complacency to take hold. In a very real sense that is why you are here. And make no mistake: the stakes you are playing for remain very high indeed.

What will the future look like? Almost certainly we will not face a hostile superpower in the near term, but the world will remain a dangerous place. There will be many who do not share our values, many who will challenge our interests, and many who will threaten our friends and allies. Some of these threats will look familiar. The nation-state, after all, will still be with us for a long time to come, and so will armies, navies and air forces much as we know them today.

But the 21st Century will also see the non-state actor come of age. Fanned by the ancient flames of ethnic, religious, cultural, and economic rivalry, many groups will challenge us at home and abroad. However, unlike past eras, terrorist groups and other non-state actors will have access to state-of-the-art technology. They will have secure communications and access to global positioning satellites, highly advanced computer technology and, perhaps most frightening of all, weapons of mass destruction. The proliferation of advanced technology with military applications has been so rapid and so pervasive that our enemies in the next century will have capabilities they could only dream about in this one.

And whether those enemies come in the form of nation-states, or rogue organizations pursuing their own agendas, they will have learned to challenge us asymmetrically -- not where we are strong, but where they think we are vulnerable.

Thus, preparing to respond to the full range of asymmetric threats should increasingly occupy our interest, our time, and our energy. Now is the time we should be doing that, now when we have a window of opportunity, when we don't have to worry about a strategic rival that could threaten our existence as a nation.

Our best thinking about how we should fight in the 21st Century is found in Joint Vision 2010, our conceptual template for future joint operations. Most of you are probably familiar with JV2010, at least in its broad outlines. The four pillars of Joint Vision 2010 are its key operational concepts: Dominant Maneuver, Precision Engagement, Focused Logistics and Full Dimensional Protection, and two "enablers" -- technological innovation and information superiority. Each of these are very powerful individually, but they are not ends in themselves.

The ultimate goal for joint warfighting in the future is decisive operations: the ability to win quickly and overwhelmingly across the entire range of operations, or in other words, Full Spectrum Dominance. We want our men and women to be the masters of any situation. In combat, we do not want a fair fight—we want capabilities that will give us a decisive advantage.

Implications

The implications of Joint Vision 2010 should be clear for us in the acquisition community. There are number of critical enablers that are absolutely essential to our ability to shape the international security environment and respond to the full spectrum of crises. Two of those are of special importance to us here today—harnessing advanced, complex technologies to achieve the desired Revolution in Military Affairs. And reengineering our acquisition process to meet the affordability challenge through a Revolution in Business Affairs.

Technology will need to be developed, tested, and sustained that can profoundly affect the warrior and leader who will execute 2010 missions.

Exploiting the Revolution in Military Affairs involves more than the acquisition of new military systems. It means leaping ahead technologically—not creeping ahead. It means harnessing these new technologies to give U.S. forces greater military capabilities through advanced concepts, doctrine, and organizations so they can dominate any future battlefield. And it means more than ever dealing with the complexity of a systems of systems approach.

The U.S. military's modernization effort is directly linked to the broader challenge of a Revolution in Business Affairs. Efforts to reengineer the Department's infrastructure and business practices must parallel the work being done to exploit the Revolution in Military Affairs if the nation is to afford both adequate investment in preparations for the future, especially a more robust modernization program, and capabilities sufficient to support an ambitious shaping and responding strategy through 2015.

I see our challenge as three-fold:

1. Conceiving, designing, developing, testing, producing, fielding, and supporting complex technologies that enable our new warfighting concepts.
2. Doing this in substantially less time. Our goal is to reduce cut the time from concept to fielding in half!
3. And doing so affordably—remarkable reducing not just the cost to acquire, but the total ownership cost.

Complexity

The nature of products and processes demanded by today's global market place is changing. So are the products required by our defense's warfighters and strategies. People often speak of the past as being a simpler time. We frequently emote that "things were not nearly as complicated." In light conversations, we "complain" that "back then" we didn't have to choose between paper and plastic, regular and decaf, or even between latte' and cappuccino.

It turns out that those conversations are not among persons who are imagining things. If you put today's economy under a microscope, the past really was a simpler time—at least from a product and process point of view. A recent found that the most successful commercial technologies

have changed in one basic way over the past quarter century: they have become more complex.

It looked at the 30 most valuable exports in the global market in 1970 and those of today. They found in 1970 nearly 60 percent of the world's top exports were essentially simple products that could be manufactured through simple processes. Today, that same percentage—60 percent—of the world's top exports are complex products that require complex manufacturing processes.

For example, 25 years ago, typewriters were one of the top products; now its PCs. And our audio players that were based on Thomas Edison's phonograph have been replaced by CD players that rely on computer chips and lasers. Certainly, those technologies that Joint Vision 2010 will rely on--low observable masking technologies, smarter weapons, long-range precision capability and information technologies—all technologies that were unknown a quarter century ago--are more complex than those of 25 years ago.

Put simply, the future belongs to those who can make sense of the complex, to those that can take an idea from conception through the functional integration of many complex technologies and disciplines to product realization, to those who can put complex technologies and products "out the door" and into the hands of users.

Today I will address five specific aspects of our strategy for meeting the RMA and RBA that I believe have particularly high leverage for us:

- Integrated Product and Process Development
- Simulation Based Acquisition
- Improved Software Engineering
- Design for Ownership
- Open Systems Approach

Integrated Product and Process Development

Success in this era will occur when different approaches and perspectives are brought together. The final value added is always greater than the sum of the parts. This places a premium on qualities that we sometimes undervalue as a society: qualities like diversity, trust and

community, and it requires that we develop an ability to bring together and reconcile those differing perspectives and approaches.

In order to do that, the Department has worked to find the best methods for reengineering its processes. In May 1995 the Secretary of Defense—then Bill Perry--directed a "fundamental change in the way we acquire goods and services" and mandated that the concepts of Integrated Product and Process Development (IPPD) and Integrated Product Teams (IPTs) "be applied throughout the acquisition process to the maximum extent possible."

The DoD defines IPPD as "a management process that integrates all activities from product concept through production/field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing and sustainment processes to meet cost and performance objectives." An outgrowth of concurrent engineering practices, the IPPD process reflects a systems engineering approach that has incorporated sound business practices and commonsense decision-making. Fundamental to the successful implementation of the IPPD concept will be the willingness of organizations to undertake and experience profound changes in their cultures and past practices.

IPPD has had many successes in industry and it fits well within the spirit of the Department's acquisition reform initiatives. It is being accomplished by integrating the "functional stovepipes," utilizing best commercial practices, and encouraging teamwork within the Department and between ourselves and industry.

At the core of the IPPD implementation are Integrated Product Teams (IPTs) that organize for and accomplish tasks that acquire goods and services.

IPPD Key Tenets

To implement IPPD effectively it has been important for us to understand the interrelated tenets inherent in it.

The first of these is **customer focus**. The primary objective of IPPD is to identify and satisfy the customer's needs better, faster, and at less cost. The customer's needs should determine the nature of the product

and its associated processes. And to be precise, within DoD the customer is not the program manager, but the warfighter.

A second tenet is that **processes should be developed concurrently with the products** they support. It is critical that the processes used to manage, develop, manufacture, verify, test, deploy, operate, support, train people, and eventually dispose of the product be considered during product design and development. Product and process design and performance should be kept in balance to achieve life-cycle cost and effectiveness objectives. Early integration of design elements can result in lower costs by requiring fewer costly changes late in the development process. **Early and continuous life cycle planning** is essential.

Third, the government's interface with industry is critical to IPPD success. Our requests for proposals (RFPs) and contracts should provide **maximum flexibility** for employment of IPPD principles and use of industry's processes and commercial specifications, standards, and practices. They should also accommodate changes in requirements and incentivize industry to challenge requirements and offer alternative solutions which provide cost-effectiveness.

Fourth for IPPD, an event driven scheduling framework should be established which relates program events to their associated accomplishments and accomplishment criteria. An event is considered complete only when the accomplishments associated with that event have reached completion as measured by the defined criteria.

Proactive identification and management of cost, schedule, and technical risk is fundamental. Technical and business performance measurement plans, with appropriate metrics, should be developed and compared to best-in-class government and industry benchmarks to provide continuing verification of the effectiveness and degree of anticipated and actual achievement of technical and business parameters.

Without a doubt, the most essential tenet of IPPD is multidisciplinary teamwork. Inherently IPPD will not work without the people part, which brings us back to the diversity issue I mentioned earlier—previously separate communities working together—for common objectives. This is teaming. Integrated Product Teams are cross-functional teams that are formed for the specific purpose of delivering a product for an external or

internal customer. IPT members, as I must emphasize, should have complementary skills and be committed to a common purpose. The right people at the right place at the right time are required to make timely decisions.

Critical to the formation of a successful IPT are: (1) all functional disciplines influencing the product throughout its lifetime should be represented on the team; (2) a clear understanding of the team's goals, responsibilities, and authority should be established among the business unit manager, program and functional managers, as well as the IPT; and (3) identification of resource requirements such as staffing, funding, and facilities.

Also critical is empowerment. Decisionmaking should be driven to the lowest possible level commensurate with risk. The team should be given the authority, responsibility, an resources to manage its product and its risk commensurate with the team's capabilities. The authority of the team members needs to be defined and understood by the individual team members. The team, on the other hand, should accept responsibility and be held accountable for the results of its efforts.

I've spoken some about IPPD as a process and some about people, but let me shift to a third focus area: tools. It is incumbent on both DoD and industry to employ state-of-the-art methods and tools, to become knowledgeable of the capabilities of those tools, and to integrate them into their internal tools sets for planning, information management, design, cost trade-off analysis, and modeling and simulation.

And while various tools are important I would like to draw particular attention to virtual prototyping as a process for replacing physical prototypes by computational prototypes which can be embedded in realistic synthetic environments to support all phases of IPPD. This we are calling Simulation Based Acquisition.

Simulation Based Acquisition (SBA)

The Defense Department, in cooperation with our industry partners, envisions an acquisition process enabled by the robust, collaborative use of simulation technology that is integrated across acquisition phases and programs. The objectives of Simulation Based Acquisition (SBA) are to:

(1) Substantially reduce the time, resources, and risk associated with the acquisition process;

(2) Increase the quality, military utility, and supportability of systems developed and fielded; while reducing their operating and sustaining costs, and

(3) Enable integrated product and process development across the full acquisition life cycle.

I will not speak long on SBA since I know it will be addressed in some detail later this morning, but let me just state that I am convinced that there is consistent and pervasive evidence already accumulated regarding the value of a simulation-based approach to acquisition. Both commercial and military programs provide substantial proof of tangible results that can be measured in terms of improvements in **cost, schedule, productivity, and quality/performance.**

It is clear that integrated product and process development, backed by a strong commitment to computer-based modeling and simulation tools, provides a dominant and competitive edge in the commercial marketplace and a distinct warfighting advantage on the battlefield.

Software Engineering Improvement

Let me turn your attention now to an area of powerful leverage for the Department--software. There has been nothing like the headlong rush to software since the similar rush to electronics after WWI. The average automobile of today has more software in it than the first Apollo spacecraft to arrive at the moon 30 years ago.

We are just beginning to appreciate that a new breed of "knowledge warriors" is emerging—recognizing that knowledge can win, or prevent, wars. And this is causing fundamental changes in what is important to our warfighting capability.

In the Gulf War, television cameras, ravenous for dramatic visuals, focused on F-14s roaring off the decks of carriers, Apache helicopters swooping over the desert, M1A1 Abrams tanks growling over the sands,

and Tomahawk missiles singing out their targets. Pieces of hardware became overnight stars. But the real star was the invisible software that processed, analyzed, and distributed data, though no television watcher ever saw those who produced and maintained it—America's software soldiers.

Software is changing military balances in the world. Today weapons systems are mounted on or delivered by what we call "platforms"—a missile, a plane, a ship, or even a truck. And what we are learning is that cheap, low-tech platforms that are operated by even poor, small nations can now deliver high-tech smart firepower—if the weapons themselves are equipped with smart software. Stupid bombs can have their IQ raised by the addition of retrofitted components dependent on software for their manufacture or operation.

Costs of Software Failure

Information or knowledge superiority may win wars. But that superiority is exceedingly fragile. Pentagon leaders have been stunned in recent months, both by learning that some of our computer systems have been tampered with by hackers and by a recent military exercise, Eligible Receiver, that demonstrated how easy it is for hackers to cripple U.S. military and civilian computer networks.

But my issue for you here today is not so much one of information assurance—although that is decidedly a top priority for the Department. Rather I want you to focus on the implication that you succeed or fail on the software. It doesn't matter how much speed, or how much stealth or how much armor plating you have; you won't succeed if the software doesn't work.

So I contend that software that does not work is self-inflicted information warfare. And the policies, processes, and practices that guide the development and use of information technology in general, and software in particular, are a crucial component of knowledge strategy.

Expectations

Unfortunately our overall track record—or the perception thereof—for producing quality software is underwhelming. According to

the results of a study on U.S. software development reported by the Standish Group in 1996:

- In 1995, only 16 percent of software projects were expected to finish on time and on budget.
- An estimated 53 percent of projects will cost nearly 190 percent of their original estimates.
- Projects completed by the largest American organizations have only 42 percent of the originally proposed features and functions.

This sort of performance record might somehow be adequate in a word processor, but it hardly seems acceptable in a weapon system or where safety is a major consideration. After all, a soldier without a weapon is at best a tourist, and more likely a target.

Systems Engineering Process

When we track successful software developments, almost invariably the accomplishment can be linked to the existence of a good systems engineering processes. It is for this reason that my office is responsible for software acquisition policy in the Department. Not because we are the focal point for information technology—because we aren't. Not because we are the office of primary responsibility for software tools and technology—because we aren't either. But because it is the application of the disciplined systems engineering process that makes the difference between achieving the functionality we seek—in both hardware and software.

All of the primary systems engineering processes must come together for both hardware and software systems development. But I will highlight two specific aspects here: Requirements management and design for sustainability.

Requirements Management

I have a cartoon in my office that shows two individuals—presumably software engineers—with one of them saying to the other as he is running out, "You start coding, and I'll go find out what they want." Unfortunately there is all too much truth in this picture. Because what is being developed is "only software"—and everyone knows

software is easy to change—a disciplined requirements management process is all too frequently lacking. Without requirements analysis up front, however, the results are unsatisfied needs, wasted effort, and rework.

Software may be easy to change—at least relative to bent metal—but it can still be costly in both time and dollars. It is estimated that rework is 40 percent of the cost of development. Metrics collected by Capers Jones indicate that the cost and schedule impact of defects in requirements are the most expensive of all defects—followed by a defect in top level design (architecture), and finally by defects in code.

Design for Sustainment

Much of the software that is operational today will still be in service several years from now—with large implications for total ownership cost. By way of example, an assessment was made for the Air Force recently of the current process for updating the software in major operational weapon systems. Such software is embodied in formally designated Operational Flight Programs (OFPs). Over the service life of software intensive aircraft and smart munitions there is a need for continuous improvement, correction, and addition of new capability via software modification.

Over the FYDP, the combined B-1, F-15, and F-16 programs alone are projected to spend nearly one billion dollars on OFPs. When the planned expenditures for the B-2, F-22, F-117, and the advanced weapons are added in, the total five years costs of OFPs is nearly two billion dollars.

As I noted earlier, approximately 66 percent of DoD's software costs are associated with maintenance. Almost all of the systems engineering practices that have high leverage for lowering the cost of maintenance are practices that need to be implemented during development. These include development practices that reduce that density of defects in the software delivered into operation; effective software test; a strong configuration management program; and taking account early in the program of the engineering environment and processes that need to be in place for sustainment.

Design for Ownership

Of course, software is not the only component of systems that needs to be designed with sustainment in mind. A large area of leverage for the Department as we seek to reduce the total cost of ownership for our systems is what I will call "Designing for Ownership." Let me explain.

On the average, ninety percent of the cost of owning a weapons system is determined in the first few years of development—with sixty to eighty percent of that ownership cost being operations and sustainment. Acquisition costs—design, test, fabrication,...--are really only a relatively small fraction of total ownership costs.

Operations costs are driven by things like consumables—fuel, ammunition—and personnel, a large cost driver. Support costs are a factor of maintenance labor, repair materials, replenishment spares, and the like. These are all factors that are designed into the system we will own.

This is one of the reasons why acquisition logistics is so critical. Acquisition logistics is multi-functional, technical management discipline associated with the design, development, test, production, fielding, and sustainment, and improvement of systems. Its principal objective is ensuring that support considerations are an integral part of the system's design requirements, that the system can be cost-effectively supported through its life cycle, and that the infrastructure elements necessary for the initial fielding and operational support of the system are identified and developed and acquired.

Acquisition logistics activities are the most effective when they are integral to both the contractor's and the government's system engineering technical and management processes. When this is the case, system designers, acquisition logisticians, and program managers are best able to identify, consider, and tradeoff support considerations with other system cost, schedule and performance parameters.

The Open Systems Approach to Weapons System Design

Another one of the ways we can design with life cycle considerations in mind is the open systems approach to weapons system design which is both a technical approach and a preferred business strategy that allows DoD to field superior combat capability quicker and at a more affordable cost.

The open systems approach defines key interfaces for a system (or piece of equipment) being developed. Interfaces generally are best defined by formal consensus (adopted by recognized industry standards bodies) specifications and standards. However, commonly accepted (de facto) specifications and standards (both company proprietary and non-proprietary) are also acceptable if they facilitate utilization of multiple suppliers.

The use of de facto specifications and standards takes advantage of the fact that firms, particularly those in the commercial arenas, frequently develop hardware, software and systems standards of the design and fabrication of computing, telecommunications, display, sensing, and signal processing systems. Whether interfaces are described by consensus or de facto standards, the benefits only accrue if products from multiple sources are economically possible. Although the most common emphasis is on electronic systems, the open systems approach is widely applicable, from fasteners and light bulbs to jet engines.

An open systems approach is designed to facilitate the use of widely accepted, standard products-from multiple suppliers-in DoD weapons systems. In addition, if the architecture is defined by specifications and standards used in the private sector, the DoD can be one of many customers to leverage the benefits of the commercial marketplace, taking advantage of the competitive pressures which motivate commercial companies to reduce prices, and introduce new products developed with internal resources.

The open systems approach can have a profound effect on the life-cycle cost of a system. Program managers can have access to alternative sources for the key subsystems and components to construct DoD systems. DoD investment early in the life-cycle is reduced since at least some of the required subsystems or components are likely to already be available, or being developed without direct DoD investment. Production sources can be competitively selected from multiple competitors.

The system design flexibility inherent in the open system approach, and the more widespread availability of conforming commercial products, mitigates potential problems associated with a diminishing defense-dependent manufacturing base. Finally, life-cycle costs are reduced by a

long-lived, standards based architecture that facilitates upgrades by incremental technology insertion, rather than by large scale system redesign.

The system architecture should be addressed early in a program to maximize the number of potential solutions, and thereby help reduce program cost. By developing the architecture early in a program, the specific technology used in its implementation can then be chosen as late as possible.

The application of the open systems approach to legacy systems is less obvious but still beneficial. Legacy systems usually have size, space, power, cooling and shape factor constraints. For these systems, the open systems approach can provide form-fit-function interface (F3I) solutions within existing packaging, power, and environmental constraints. In such cases, the open systems solution frequently requires less system resources by using newer, more efficient technologies. The open systems approach is similar to F3I except that the open systems approach emphasizes choosing interfaces that are broadly accepted in the marketplace to allow for as many suppliers as possible over the long term.

Closing

At the end of the day we will field a Joint Force of unmatched capability and versatility. How good will we be? Let me paint a picture for you.

In the Joint Force of 2010, we'll be able to detect the launch of a ballistic missile, identify, target and attack the launch platform, alert all units in the impact area, and attack and destroy the incoming missile all in a matter of a very few seconds. The ability to transfer information that fast, across service and even national boundaries, in the fog and friction of war, using joint language that we all understand, will be nothing less than revolutionary.

Most of you are probably thinking this is General Shelton's job, or Secretary Cohen's, but it's really not. It's your job, because only you and your counterparts can make this happen on the battlefield. I expect every acquisition professional to be part of the team making our national strategy work—making Joint Vision 2010 a reality. Remember, your theme is "meeting the technology needs of the warfighter in the year 2000 and

beyond." Remember also that our challenges include not only meeting those technology needs, but doing so quickly and affordably.

I have discussed a number of strategies or initiatives that I believe will contribute to engaging those challenges—IPPD, Simulation Based Acquisition, improved software engineering, designing with total ownership in mind, and open systems approaches. Undoubtedly these strategies and others will be discussed in more detail here this week.

Because of the unprecedented opportunities and challenges emerging from the rapidly changing technologies enveloping us today, I cannot emphasize too much our need to work together to succeed. We must rely on each other now more than ever before.

The fact that our economy, and indeed our way of life, and certainly our defense, is now shaped and dominated by technological products of inordinate complexity means that we must see beyond the limits of our individual perspectives and achieve the breakthroughs that occur only through the synthesis of widely different skills and points of view. True progress within an envelop of complexity occurs only through an appreciation of mutual benefit.

Whatever our individual challenges, if we join our talents and work together, we can and will meet those challenges.

Many of the discussions on the agenda for this symposium will address what you are doing to "meet the technology needs of the warfighter." Peter Drucker has said that ours is a world in which knowledge, not labor, not raw materials, not capital, but knowledge, is the key resource . This meeting is your opportunity to increase your knowledge, and to share your knowledge. I strongly encourage you to take the maximum advantage of this opportunity.

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